Trip Generation Rates for Urban Infill Land Uses in California

THE STUDY DEFINED CRITERIA FOR IDENTIFYING URBAN INFILL AREAS, IDENTIFIED INFILL LAND USES BENEFICIAL TO THE REVITALIZATION OF URBAN AREAS, DEVELOPED A SURVEY INSTRUMENT FOR COLLECTING TRIP GENERATION AND MODE SHARE DATA AND CONDUCTED SURVEYS TO ESTABLISH AN INITIAL STATEWIDE DATABASE.

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INSTITUTE OF TRANSPORTATION Engineers (ITE) trip generation rates have been the primary source for travel demand analysis of new development throughout the United States. In California they are relied upon for conducting California Environmental Quality Act (CEQA) and local agency development impact analyses. These rates are limited as they are based almost solely on surveys of isolated suburban development with little or no pedestrian, bicycle, or transit accessibility for ease of data collection.

Despite the vast amount of data collected by ITE over the past decades, these trip generation rates are not sufficient to guide the approval of proposed developments in urban infill areas because the sources of the rates do not reflect variations in density, diversity (land use mix), site design and the multimodal transportation systems of larger metropolitan areas, which are critical factors in travel demand. ITE's *Trip Generation Handbook* states that local trip generation studies should be conducted when the study site is located in a downtown setting or served by significant public transportation.[1] ITE recognizes that, in metropolitan areas, the amount of vehicle trip generation is affected by multiple factors that include proximity to transit, density of development, development compactness, pedestrian environment and the cost of parking, to name a few.

Because the ITE trip generation rates do not account for the variations in these factors, sometimes speculative adjustments are made in impact analyses to estimate urban and multimodal travel demand. Increased interest in land use typologies such as "mixed-use" and "transit-oriented" development (TOD) has led to particular challenges and debate when it comes to travel demand analysis. Transportation and land use planners and engineers are seeking credible empirical trip generation and mode share data to more accurately assess the impacts and benefits of new development in complex urban land use/transportation systems.

In 2004, the California Department of Transportation (Caltrans) undertook a research project to address the need for better and more accurate data regarding travel characteristics of infill development in California's metropolitan areas.[2] The two primary objectives of this study were to:

- Develop a methodology for identifying and describing urban infill locations and for collecting trip generation rate data in urban infill areas of California.
- Establish a database of trip generation rates for common infill land use categories in urban areas of California.

The study was guided by a technical advisory committee comprising land use and transportation professionals representing public agencies and the consulting industry throughout California.

CURRENT STATE OF TRIP GENERATION DATA FOR URBAN INFILL DEVELOPMENT

A review of recent and ongoing research concludes that, while there are a number of studies related to trip generation, few are specific to urban infill development and even fewer collect empirical data. Most of the research projects are specific to a unique type or pattern of development (i.e., TOD or multi-use development) that may or may not also be located within infill areas.

Transportation professionals who evaluate the transportation-related impacts and benefits of proposed development projects have various tools at their disposal to estimate trip generation. However, they recognize the limitations of the available data for assessing urban infill and acknowledge the need for new research. As many local jurisdictions implement smart growth and more sustainable land use and transporta-

tion strategies, it has become clear that, as a profession, transportation professionals lack appropriate data and tools to accurately assess the impacts and benefits of proposed urban infill, transit-oriented and mixed-use development projects.

DEFINING URBAN INFILL

As an initial step in the measurement of urban infill trip generation, it is necessary to define what constitutes urban infill. The terms "urban" and "infill" are common throughout the disciplines of land use and transportation planning. Practitioners in these disciplines generally understand the term "urban" and often rely on established definitions such as the Census Bureau's classification of urbanized areas or urban clusters, or ITE definitions in the publications *Parking Generation* and *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities: An ITE Proposed Recommended Practice*.[3–5] The term "infill" is commonly used to describe the development of vacant or under-utilized land in areas surrounded by existing development.

The collective term "urban infill" usually describes the redevelopment of blighted areas or policies aimed at preventing sprawl. Table 1 presents some common definitions and interpretations of urban infill development. Although transit proximity is not explicitly included in the common definitions, many practitioners believe that access to transit, TOD and mixed-use development are typically associated with urban infill development. The California Urban Infill Trip Generation study established specific criteria used to select study sites within urban infill areas:

1. Site must be located either within a central business district (CBD), central city, not downtown (CND), or suburban center (SBC) area (4); or within a general urban (CZ-4), urban center (CZ-5), or urban core (CZ-6) context zone, as defined by ITE.[6]
2. Site must be within one-third-mile of an existing or future rail transit station, a ferry terminal served by either bus or rail transit service, an intersection of at least two major bus routes, or within 1,200 feet of a bus rapid transit corridor. Transit service must have maximum scheduled headways of 15 minutes for at least five hours per day to qualify. It is acceptable to use the collective headways of multiple routes as long as the routes serve the same corridor for a considerable distance. These criteria were based on existing California statute.[7]
3. Site must be within an urban infill area that contains no more than 10 percent vacant developable land, including surface parking lots on land designated and/or zoned as developable under current policy.
4. Site must be located within an area that meets one or more of the following density criteria:
   i. where residential land uses comprise at least 60 percent of developed land, average residential density shall be at least 10 dwelling units per gross acre, or
   ii. where nonresidential land uses comprise at least 60 percent of developed land, average employment density shall be at least 35 jobs per gross acre, or
   iii. where neither residential nor nonresidential uses comprise more than 60 percent of developed land, both residential and nonresidential uses must meet the density and intensity criteria prescribed above.
5. Additional qualitative criteria considered in selecting sites for this study include the following:
   i. Only mature sites that have had time to become fully occupied qualify.
   ii. Regional-destination retail shopping centers that attract traffic from a larger market area than typical infill development were not included.
   iii. The ability to cost-effectively collect travel data is important because large and complex sites are difficult to survey and verify that all trips have been captured.
   iv. The property owner/manager must provide permission to conduct intercept surveys at the site, not only as a courtesy but also to obtain necessary independent variable data (such as building size, number of units and level of occupancy).
   v. The site must be located in a district that is "walkable" (see definitions in Reference 1).

Table 1. Common definitions of urban infill.

Development/redevelopment of vacant or underutilized parcels within a primarily developed or built-out area.
The use of vacant land within a predominately developed area that contains existing public services and infrastructure but may require improvements to meet current development standards.
Development and/or redevelopment of a nearly built-out area; generally focused in moderate-to-high density urban, suburban, or former industrial areas.
Adaptive re-use of existing structures or infrastructure, often resulting in greater intensity of use through higher densities.

Source: From survey of members of the Institute of Transportation Engineers and the Congress for the New Urbanism, 2008.

SELECTING URBAN INFILL STUDY SITES

This study was intended to produce trip generation data for at least 10 infill land uses, including residential, office, retail, restaurants and other commercial land uses typical of urbanized areas. The land use selection criteria included land use types:

- that are common, consistent with ITE categories and reflect a range of uses within residential, office and retail categories;
- for which there is a demand for empirical trip generation data based on professional knowledge and frequent applications for development review;
- where there is a reasonable propensity for shifting drivers to another mode of travel if the use is located in an urban area; and

- that are considered beneficial to the revitalization of urban areas, and for which the use of current trip generation data may act as a barrier to development approval and to providing appropriate and adequate mitigation.

Because parking availability and costs are often of crucial importance to the types and modes of trips generated by urban infill sites, consideration in choosing candidate uses was also given for those land use types already represented in ITE's *Parking Generation*.[8]

The land use types established by the technical advisory committee are shown in order of priority in Table 2.

Table 2. Selected Land Use Categories for this study.

ITE Land Use Code	Land Use Category
230	Residential Condominium/Townhouse
710	General Office Building
232	High-Rise Residential Condominium/Townhouse
223	Mid-Rise Apartment
222	High-Rise Apartment
814/820	Specialty Retail Center/Shopping Center
880	Pharmacy/Drugstore without Drive-Through Window
310	Hotel
933, 939, 936	Fast-Food Restaurant without Drive-Through Window, Bread/Donut/Bagel Shop without Drive-Through Window, Coffee/Donut Shop without Drive-Through Window
931	Quality Restaurant

LIMITATIONS OF THE CONVENTIONAL TRIP GENERATION DATA COLLECTION METHODOLOGY

The conventional approach for collecting vehicular trip generation data, outlined in the ITE *Trip Generation Handbook*, relies on traffic counts established at the access points of the subject site. When studying a single land use type, this approach requires that the site be a standalone facility with its parking dedicated only to that site, and isolated enough so that visitors to the site do not park off-site and walk.

Therefore, by definition, sites that meet the ITE requirements are typically isolated locations with ample, dedicated free parking and little transit and pedestrian accessibility. These limitations are the underlying reasons why ITE trip generation rates may not be accurate when used to assess urban infill development.

By its very nature, urban infill development cannot be studied using the conventional approach because it would not capture all the vehicle trips likely to be generated by the site. The characteristics of urban infill development users (including residents, employees, customers and visitors) that lead to this conclusion include the following:

Table 3. Comparison of observed and ITE trip rates for residential land uses.

		a.m. Peak Hour			p.m. Peak Hour		
Land Use	Location	Observed Trip rate	Avg. ITE trip rate (ITE code)	Percent difference between observed and ITE rate	Observed Trip rate	Avg. ITE trip rate (ITE code)	Percent difference between observed and ITE rate
Mid-Rise Apartments	Berkeley, CA	0.04	0.30 (223)		0.28	0.39 (223)	
Mid-Rise Apartments	Santa Monica, CA	0.25			0.25		
Mid-Rise Apartments	Pasadena, CA	0.34			0.32		
Weighted Average of Mid-Rise Apartment Sites		**0.22**		-27%	**0.28**		-28%
High-Rise Apartments	San Francisco, CA	0.05	0.30 (222)	-83%	0.07	0.35 (222)	-0.80
Mid-Rise Residential Condominiums/Townhouses	San Diego, CA	0.46	0.44 (230)	5%	0.41	0.52 (230)	-21%
High-Rise Condominiums/Townhouses	San Diego, CA	0.10	0.34 (232)	-71%	0.17	0.38 (232)	-55%
Weighted Average of All Residential Sites		**0.17**			**0.32**		

* Note: Average ITE trip rates from *Trip Generation, 8th Edition*. ITE average trip rate for peak hour of adjacent street traffic was used for comparison, except where noted.

Table 4. Comparison of observed and ITE trip rates for non-residential land uses.

Land Use	Location	a.m. Peak Hour			p.m. Peak Hour		
		Observed Trip rate	Avg. ITE trip rate (ITE code)	Percent difference between observed and ITE rate	Observed Trip rate	Avg. ITE trip rate (ITE code)	Percent difference between observed and ITE rate
General Office Building	San Francisco, CA	1.21	1.55 (710)		0.92	1.49 (710)	
General Office Building	Los Angeles, CA	0.81			0.62		
General Office Building	Los Angeles, CA	0.28			0.50		
General Office Building	Los Angeles, CA	0.60			0.95		
Weighted Average of Office Sites		**0.78**		**-50%**	**0.74**		**-50%**
Retail Clothing Store[1,3]	Oakland, CA	12.03	N/A	N/A	4.01	3.73 (820)	8%
Flower Shop[3]	Berkeley, CA	0.83	1.00 (820)	-17%	2.92	3.73 (820)	-22%
Bakery & Cafe	Berkeley, CA	5.21	70.22 (939)	-93%	8.46	28.0 (939)	-70%
Coffee Shop	San Diego, CA	50.80	117.23 (936)	-57%	8.77	40.57 (936)	-78%
Quality Restaurant[2]	San Francisco, CA	4.56	5.57 (931)		4.2	7.49 (931)	
Quality Restaurant[2]	San Francisco, CA	1.75			8.29		
Weighted Average of Quality Restaurant Sites		**3.62**		**-35%**	**5.56**		**-26%**

* Note: Average ITE trip rates from *Trip Generation, 8th Edition*. ITE average trip rate for peak hour of adjacent street traffic was used for comparison, except where noted.

1. ITE *Trip Generation* does not provide a weekday rate for "peak hour of the generator" for shopping centers. The trip generation manual provides rates for "apparel store" (Code 876). The average p.m. peak hour rate for this land use is 3.83 trips per KSF and 4.20 trips for the p.m. peak hour of the generator.
2. The restaurants were closed during the a.m. peak hour. Therefore, the restaurants were surveyed during the midday period (11:30 a.m.–2:00 p.m.). For comparative purposes, the ITE 931 rate for the a.m. peak hour of the generator is shown above.
3. ITE *Trip Generation* does not provide specific trip generation rates for each of the different types of retail land uses included in this study; therefore, the technical advisory committee chose to compare all forms of retail to ITE *Trip Generation*'s Shopping Center Land Use Category (Code 820).

- Users can park in off-site facilities and walk to a site that may have limited, expensive, or no on-site parking.
- Users can park on-street, sometimes many blocks away from the site.
- Users in urban contexts often link trips to multiple purposes and uses/destinations.
- Residents of urban residential development may park additional vehicles off-site if their residence cannot accommodate all vehicles.

For these reasons, it was determined that counting and surveying site users were the best means of collecting not only vehicular trip generation data but also mode share data.

URBAN INFILL TRIP GENERATION DATA COLLECTION METHODOLOGY

Intercept surveys conducted during the morning and afternoon peak periods were selected as the preferred method of data collection. The intercept surveys collected travel information from users of the selected sites and were also used to derive automobile trip generation rates for the time periods under study.

Intercept surveys rely on random sampling of the entire population of the site and assure that each element in the population has an equal chance of being selected; therefore, the results can be applied to a total population. This method is relatively easy to implement and can specifically target a site, business and time period. The statistical reliability for this approach is relatively high and, unlike other types of surveys, it avoids the problem of identifying individuals to survey and the need to follow-up. Limitations include the potential to miss a portion of the population, the need to ensure that the total population (i.e., everyone entering and exiting a site) is captured during the survey period and obtaining an adequate response rate (i.e., people willing to take the time to respond). An initial pilot study was conducted to test this method.

In addition to conducting intercept surveys, the study collected data on independent variables regarding site and context characteristics (e.g., number of dwelling units, square footage, occupancy).

Table 5. Observed mode of travel by residential Land Use Category.

Land Use	Location	a.m. Peak Hour			p.m. Peak Hour		
		% Auto trips	% Transit trips	% Walk/ bicycle trips	% Auto trips	% Transit trips	% Walk/ bicycle trips
Mid-Rise Apartments	Berkeley, CA	20%	7%	73%	24%	5%	73%
Mid-Rise Apartments	Santa Monica, CA	84%	0%	16%	62%	3%	35%
Mid-Rise Apartments	Pasadena, CA	85%	9%	6%	85%	5%	10%
Weighted Average of Mid-Rise Apartment Sites		**67%**	**5%**	**28%**	**60%**	**4%**	**36%**
High-Rise Apartments	San Francisco, CA	14%	61%	25%	17%	49%	34%
High-Rise Residential Condominiums/ Townhouses	San Diego, CA	77%	3%	20%	73%	7%	20%
Mid-Rise Residential Condominiums/ Townhouses	San Diego, CA	85%	2%	13%	69%	0%	31%
Weighted Average of All Residential Sites		**51%**	**26%**	**23%**	**47%**	**21%**	**32%**

Independent variable data were used to: derive trip generation rates, document site and context, explain differences observed among trip generation rates, further classify land uses by context and provide information for future cross-referencing. Site characteristic data included:

For residential sites: total number of dwelling units and number of bedrooms.

- For commercial sites: gross leasable square feet (GLA). For sites with multiple uses, individual GLA by type of use was collected.
- The percent occupancy of the study site at the time of the survey.
- The number of parking spaces provided within the site and the cost of on-site parking. If off-site parking is provided, then the number of off-site parking spaces provided, their location and cost.
- The total number of access points (entrance and exits) for the site's buildings.
- Photographs of the site and its surroundings, including an aerial photograph.

The surrounding context data included:

- A description of predominant land-uses within a one-half-mile radius of the site.
- A qualitative estimation of street connectivity (one measure of the walking environment).
- Percent of blocks with sidewalks within one-half-mile of site.
- Distance from a CBD.
- Surrounding residential density and employment intensity.
- Area type and context zone as defined by ITE.[9,10]

OVERVIEW OF OBSERVED TRIP GENERATION RATES BY LAND USE

Unfortunately, due to the current economic recession, the study's goal of providing at least five data points for each of the 10 prioritized land use categories was not achieved before the data collection effort was suspended in fall 2008. Because of the small sample size (26 sites were surveyed), the data are not statistically significant. However, the data that were obtained provide some insight into the differences in travel patterns between urban infill and conventional suburban sites and establishes the beginning of an urban infill trip generation database.

The trip generation rates for the sites surveyed in the study (the observed rates) were derived by estimating the number of vehicle trips (from surveys and pedestrian counts) and dividing these trips by the independent variable (GLA of the building or number of dwelling units). Vehicle trips are the sum of all vehicle related trips (drove alone, passenger and taxi) and are estimated by applying the applicable mode shares (derived from intercept surveys) to the highest hour of site pedestrian counts in either the morning or afternoon peak periods. A comparison of the observed and ITE trip generation rates for residential and nonresidential categories are shown in Tables 3 and 4, respectively.

An overall finding for the limited data collected to date is that the observed trip generation rates are generally lower (in some cases significantly) when compared to ITE trip generation rates, although some individual sites show trip rates equal to or higher than ITE rates.

OVERVIEW OF MODE OF TRAVEL BY LAND USE

Tables 5 and 6 summarize the observed mode of travel by land use category and site during the peak hours. For residential sites, the automobile mode ranges between 14 percent and 85 percent for individual sites with a weighted average for all sites of 47 to 51 percent. For office sites, the automobile share ranges from 56 percent to 95 percent with a weighted average of 77 to 87 percent. Retail sites showed a broad range of mode share depending on specific type of use and context. Non-residential sites with the highest non-automobile mode shares were located in urban areas with high levels of transit service, walkable environments and proximity to a diverse range of land uses.

RESEARCH CHALLENGES

This study encountered a number of challenges in the implementation and, ultimately, the cost of collecting urban infill trip generation rates data. Although identifying and selecting appropriate sites and even conducting the surveys and counting users were relatively simple and straightforward processes, significant difficulties were encountered related to gaining permission to conduct surveys from property owners and managers. This process included iden-

Table 6. Observed mode of travel by non-residential Land Use Category.

Land Use	Location	a.m. Peak Hour			p.m. Peak Hour		
		% Auto trips	% Transit trips	% Walk/ bicycle trips	% Auto trips	% Transit trips	% Walk/ bicycle trips
General Office Building	San Francisco, CA	69%	16%	15%	56%	31%	13%
General Office Building	Los Angeles, CA	95%	4%	1%	77%	23%	0%
General Office Building	Los Angeles, CA	92%	5%	3%	94%	6%	0%
General Office Building	Los Angeles, CA	94%	4%	2%	93%	2%	5%
Weighted Average for Office Sites		**87%**	**8%**	**6%**	**77%**	**18%**	**5%**
Retail Clothing Store	Oakland, CA	-	-	-	36%	52%	12%
Flower Shop	Berkeley, CA	100%	0%	0%	100%	0%	0%
Bakery & Cafe	Berkeley, CA	33%	11%	56%	57%	10%	33%
Coffee Shop	San Diego, CA	50%	13%	37%	17%	0%	83%

tifying, contacting and ensuring follow-through with the appropriate person(s) to gain permission. However, frequently, permission was needed from national corporate offices or multiple levels of management, which was difficult to obtain.

Another significant challenge was an apparent lack of understanding or interest by property owners and managers in the research objectives. Most property owners and managers deal with many day-to-day issues and have little time to coordinate with a research project. Unlike land use developers, they do not experience the challenges and complexities of typical local development approval and mitigation processes. Site representatives often cited "tenant privacy," "internal policies," "security concerns," or other reasons why intercept surveys cannot be conducted. Attempting to resolve these challenges was a learning process, as various strategies were tried with varying results.

The strategies that were eventually found to be the most successful included: providing a brief, concise and easy-to-understand "fact sheet" that describes the research, its objectives and how it is conducted; partnering with individuals or organizations who understand the benefits of the research study and were willing to promote it to their constituents, associates and peers, such as professional or industry organizations, downtown or business associations, local or regional politicians and high level corporate officers; and hiring subcontractors within the property management industry who have a thorough knowledge of the real estate and commercial leasing market and have developed relationships with property management organizations, developers and real estate professionals. ■

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6. Ibid.

7. California Senate Bill (SB) 1636 (Figueroa) sponsored by the Surface Transportation Policy Project and signed in to law on September 12, 2002, and California Government Code Section 65088.1.

8. Institute of Transportation Engineers, note 4 above.

9. Census 2000 Urban and Rural Classification, note 3 above.

10. Institute of Transportation Engineers, note 4 above.

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